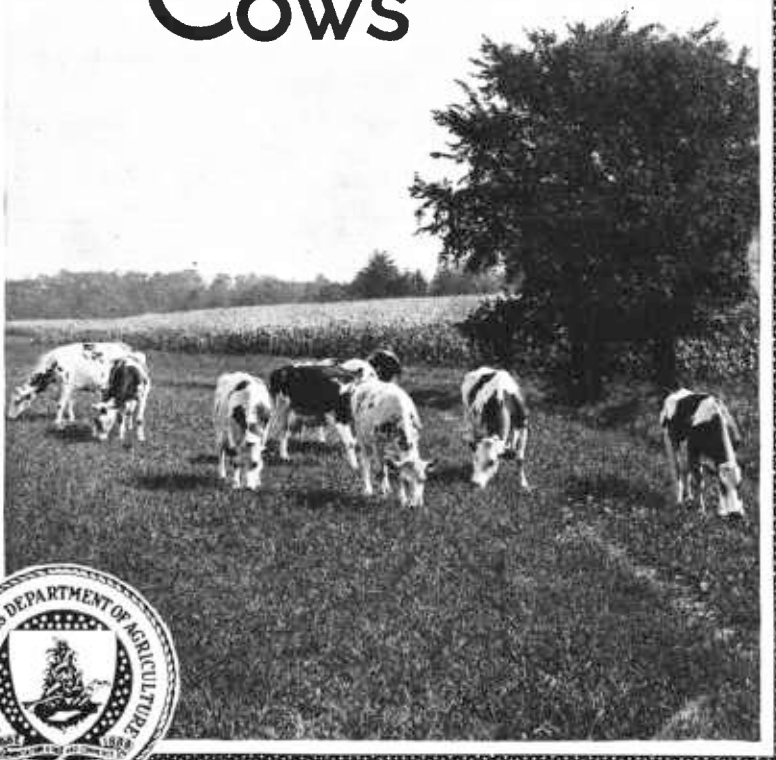
REVISED

U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1626

Feeding Dairy Cows



THE FEED of the dairy cow constitutes about one-half the expense of milk production. Profitable milk production, therefore, demands close attention to the matter of feed. The ration must be adequate in quantity, suitable in quality, but as low in cost as possible. The quantities of feed to be given the cow for most economical production have been determined with a fair degree of accuracy. The object of this bulletin is to state in simple terms some of the principles of dairy-cow nutrition and to assist the dairyman in preparing economical rations for his cows.

This bulletin supersedes Farmers' Bulletin 743, The Feeding of Dairy Cows.

Washington, D. C.

Issued April 1930
Revised May, 1936

FEEDING DAIRY COWS

By T. E. WOODWARD, *senior dairy husbandman, Division of Dairy Cattle Breeding, Feeding, and Management,* and A. B. NYSTROM, *senior dairy husbandman, Administrative Division, Bureau of Dairy Industry*

CONTENTS

HOW A DAIRY COW USES HER FEED

THE RATION of a dairy cow is used for five main purposes, namely, maintenance, growth, body fat, development of fetus, and milk production.

A maintenance ration is an amount of feed equivalent to that needed to keep the cow at constant weight when not giving milk or carrying a calf. It is used to keep the vital organs functioning properly, to replace worn body tissue, to maintain body temperature, and to provide energy for muscular activity, such as standing or moving about. The maintenance ration must be considered somewhat as a necessary overhead expense. The quantity required varies in general with the weight of the animal.

An immature animal uses a portion of its feed for growth. For this reason it needs a larger ration than a mature animal of the same weight. The ration for growth requires somewhat more protein than does the maintenance ration.

The feed needed for body fat is of no considerable consequence except during the time when the cow is dry or nearly so; at this time she is storing up a reserve to use after calving.

When the cow is carrying a calf she needs extra feed to provide for the development of the fetus and the membranes and fluids coexistent with pregnancy. The quantity of feed required for these purposes is not large but is sufficient to be considered.

The feed required for the production of milk depends on the quantity and composition of the milk. The greater the quantity and the richer the milk, the greater the quantity of nutrients needed in the feed. When a cow is underfed she diverts some of the nutrients from maintenance to milk. She loses flesh, and the yield of milk also declines.

IMPORTANCE OF THE VARIOUS FEED CONSTITUENTS

PROTEINS

Proteins in the feed are used to make the proteins of milk, blood, lean meat, and all nitrogenous body tissues. They are used in the repair of parts broken down in the ordinary course of bodily activities. For the purposes enumerated no other constituent can take their place. In addition to these uses proteins can also be employed in making fat and providing energy.

Proteins are made up of various amino acids. If a cow is to produce all the milk of which she is capable by inheritance she must receive a sufficient amount of each of the various amino acids used for maintenance and milk production. Since different proteins contain different proportions of the amino acids, the cow needs not only an ample quantity of protein but also various kinds of this constituent. This will usually call for the feeding of materials derived from several species of plants. When the constitution of the proteins and the characteristics of the amino acids become better known it may be possible to reduce both the quantity of proteins and the number of the sources from which they are obtained. All feeding standards specify an amount of digestible protein somewhat in excess of that found in milk. A moderate excess is not known to be detrimental to the health of the animal. Furthermore, since the proteins not used for milk production can be used to make fat or energy, they are not necessarily wasted. The fact that in most dairy sections of the United States feeds high in protein are more expensive than those low in this constituent is probably the main reason for using a ration containing the smallest quantity needed for continuous high production.

CARBOHYDRATES

The principal substances in feeds making up carbohydrates are starches, sugars, and crude fiber. These are used to maintain body heat, to make body fat and milk fat, and to provide energy for every muscular activity, such as mastication, respiration, and locomotion. Crude fiber is the least digestible of these substances. Feeds containing more than 18 percent of fiber in the dry substance may be classed as roughages, and those containing less as concentrates. Carbohydrates are more plentiful than proteins and are usually cheaper. This is one reason why it is generally unwise to use proteins for any purpose that carbohydrates will serve.

FATS

Fats in feeds are used for the same general purposes as carbohydrates, but on the basis of equal weights of each they are about two and one-fourth times as efficient as carbohydrates. They also lubricate the digestive tract and aid in making a glossy coat. Since most rations probably contain fats in sufficient quantities for satisfactory nutrition, no special consideration need be given the fat content in the preparation of the ration.

MINERALS

Minerals comprise a variety of compounds which exert an important influence on many of the physiological processes of the animal body and are as necessary as the other constituents of the ration.

They are used principally to aid digestion, to make bone, to provide the mineral matter in the milk, to build up the body, and to aid in the functioning of all organs in general.

Cows must have feed containing enough minerals of the proper kind or they will draw on their body stores and eventually decline in production. Other ill effects such as stiffness, enlarged joints, lack of appetite, depraved appetite, and cessation of oestrum can sometimes be traced to lack of minerals. In some sections pregnant cows fed rations deficient in iodine are likely to give birth to calves with goiter.

WATER

Water is the great carrier of food material within the body of the animal. It makes blood a fluid so that it can circulate. Many substances must be dissolved in water before they can be absorbed from the digestive tract. Waste materials are dissolved in water and eliminated as urine and perspiration. By its evaporation from the skin and lungs water controls body temperatures. Water, then, is a necessary constituent of practically all excretions or secretions, including milk. Animals will live much longer without food than without water.

VITAMINS

The term "vitamin" is a group name for certain substances, other than proteins, fats, carbohydrates, and minerals, which have been discovered to be necessary in animal nutrition. These vitamins occur in minute quantities in natural food materials. Those studied have been named A, B, C, D, E, and G. Vitamin B is sometimes called B_1 or F, and vitamin G is sometimes called B_2. Both of these vitamins were formerly called B. Most vitamins are recognized by their physiological effects rather than by their physical or chemical properties. Vitamins are essential to the life and health of animals.

Vitamin A appears to be the one most likely to be deficient in the ration of the dairy cow. This vitamin controls growth and influences resistance to infections. Carotene, the yellow pigment of the plant from which vitamin A is formed in the animal body, occurs in close association with the green coloring matter of pasture plants and other green forage and also with the green coloring matter of cured roughages, though in carrots and yellow corn it occurs in dissociation with the green color. As a rule the greener the color of the hay, the greater the content of carotene.

Ordinarily, silage made from fresh green plants and packed tightly enough to force out and keep out the air will have a high content of carotene. The green color of such silage may be greatly reduced in the fermentation process and the content of carotene still be high. The green color of silage, unlike that of hays, is a very imperfect indication of its carotene content. Fresh green forage, green-colored hay, and silage are the common sources of vitamin A for dairy cattle and herbivorous animals though cod-liver oil is often fed to certain smaller animals to provide vitamin A.

Cows fed for extended periods on a ration deficient in carotene or vitamin A may give birth to weak, dead, or premature calves. Although the quantity of milk produced by cows fed on a carotene-deficient ration may not be materially affected, the content of carotene and vitamin A in the milk is much reduced. Calves fed the milk from cows that have been on a carotene-deficient ration for some time

will cease to grow and will soon die unless they are given supplementary feeds rich in vitamin A or carotene. A reserve supply of vitamin A is stored in the liver and because of this cows may sometimes live for months on a ration deficient in vitamin A or carotene without any noticeably bad effects.

Vitamin D or some unidentified property of pasture grass, or of other green forage, or of hay cured with much of its natural green color, is useful in promoting the assimilation of calcium and the retention of calcium within the animal body. The other vitamins, if actually essential to the proper nutrition of dairy cows, have never been proved to be so deficient in any of the ordinary rations that their lack caused trouble.

Pasture grass or other green forage, silage made from a green crop, or a hay that has retained much of its natural green color, fed for at least a portion of the year, is essential to the continued well-being of dairy cows. Otherwise cows will suffer from a vitamin A deficiency and possibly also from a mineral deficiency.

PROCESS OF DIGESTION

The cow's stomach is divided into four compartments. Apparently cows chew their feed and mix it with saliva only enough to permit it to be swallowed into the large compartment of the stomach known as the rumen or paunch. This compartment acts as a reservoir and softens the coarse feed through the action of body heat and mixing with water. It appears also that the action of certain bacteria in the paunch may be beneficial.

Cows chew their cud and thus further reduce the size of the feed particles so that they may pass to the other compartments of the stomach. Any feed that is in a sufficiently fine state of division may pass on directly without being rechewed. The paunch is never empty; additional feed enters every time a cow eats, and the new and old materials are mixed. Although some of the roughage, such as hay, passes through the digestive tract in about 1½ days, some of it remains in the body for 10 days or more.

The next compartment of the stomach is known as the reticulum or honeycomb. Its contents are more watery than those of the paunch. Foreign material, such as gravel and pieces of metal, collects here and remains. Sometimes a sharp piece of wire or nail penetrates the wall of this compartment, with fatal results.

The third compartment is called the omasum or manyplies. Across it are divisions resembling leaves of a book, and it is between these leaves that the food passes. The contents of this compartment are much drier than those of the others.

Although some absorption of nutrients into the blood takes place through the walls of the first three compartments, the main function of these compartments appears to be the preparation of the food for the action of the fourth and last compartment, or true stomach, known as the abomasum. It is here that the digestive juices act on the proteins and convert some of them into a state in which they can be absorbed through the walls of the stomach.

The food then enters the intestines, where it is further acted upon by the bile, pancreatic juice, and other juices, which digest the fats and carbohydrates as well as some of the proteins. Most of the food absorption takes place through the walls of the intestines.

CHARACTERISTICS OF FEEDS

All feeds for dairy cattle are commonly assumed to fall into two general classes—roughages and concentrates. Roughages may be either green or dry. The fiber content of both green and dry roughage on the basis of dry matter is relatively high. Green roughages are pasture grasses or other fresh green forages, and closely related to these are the silages. Dry roughages are the hays, straws, fodders, and some of the byproducts from mills.

Concentrates are generally either the seeds of plants or the byproducts of such seeds when they are milled in the manufacture of human food or in the expression of oil. Byproducts of the dairy and meat-packing industries are also classed as concentrates. In fact, any material which has a low content of fiber when reduced to a dry basis is considered a concentrate.

HAYS

The importance of good hay can hardly be overestimated. By good hay is meant hay that has been cut early and cured in such a way that most of its leaves and much of its natural green color are retained. Such hay contains more protein, less fiber, more carotene, more leaves, and fewer stems than poor hay. It is also softer and more palatable. The mineral matter of green-cured hay is more completely used than that of hay which has become discolored through exposure to dew or rain.

Although legume hays are generally superior to the nonlegumes in content of protein and mineral matter and in palatability, much depends upon the soil on which the hays are grown and on the way in which they have been made. A grass hay, for instance, grown upon a soil that is rich in lime and phosphorus, cut early, and nicely cured, may be superior in many respects to a legume hay. A legume hay is not necessarily good merely because it is a legume, nor is a grass hay necessarily poor because it is a grass.

All dairymen, whether they raise their own hay or buy it, should be able to determine, by observation, the quality of the various classes and grades of hay, as given in the United States Department of Agriculture Handbook of Official Hay Standards, for 1932.

The following statement [1] made with reference to alfalfa-hay production and marketing may be applied in general to all hays:

> (1) Early cut, leafy, and properly cured alfalfa from any region has more feed value than overripe, stemmy, and properly cured alfalfa from the same region or any other region; (2) alfalfa from any region, so cured as to retain a high percentage of leaves, has more feed value than alfalfa from the same region or any other region that was so cured as to shatter a high percentage of leaves from the stems prior to baling; and (3) early cut, leafy, and properly cured alfalfa from any region has more feed value than early cut, severely bleached, and rain-damaged alfalfa from the same region or any other region. Similar comparisons and conclusions may be made with respect to the feed value of various cuttings.

LEGUME HAYS

Legume hays appear desirable for the proper nutrition of the dairy cow when pasture or other green feed is not available. In most sections of the United States they yield more nutrients per acre than do nonlegumes and provide protein at a lower cost. Good legume hay

[1] U. S. Department of Agriculture, Bureau of Agricultural Economics. U. S. Standards Reflect the Approximate Value of Alfalfa, 5 pp. 1930. [Multigraphed.]

is cured so as to retain its green color, is fine stemmed, and contains a large proportion of leaves to stems. Twenty-eight pounds of alfalfa leaves contain as much protein as 100 pounds of stems. For supplying vitamins, good legume hay and silage take the place to some extent of fresh, green forage.

Alfalfa is the best hay for dairy cows (fig. 1). It is more palatable than clover, is more easily cured than the annual legumes, and when fed, is more completely consumed than is either soybean or cowpea hay. Wherever alfalfa grows successfully it should be raised in preference to any other legume.

Although cows will eat no more of the clovers than they will of the annual legumes, there is usually less waste in feeding the clovers on account of their finer stems. Because of their fine stems also they cure more readily, and are therefore less liable to damage from rains. The clovers are rather uncertain crops. The stand is sometimes poor, and they are subject to winterkilling. No doubt this fact is responsible for the usual practice of seeding timothy or other grass along with the clover for if the clover fails the grower still has timothy.

Either soybeans or cowpeas can be raised successfully over a wide range of climatic and soil conditions. They grow on soils containing less lime than will the clovers or alfalfa, and they are especially valuable as catch crops for hay. Soybeans, being more upright in their growth and thus more easily harvested, are usually preferred to cowpeas.

The lespedeza hays, both common and improved varieties, are coming into more general use in the South, especially on acid soils. They make excellent hay, and some very good yields on rich soil have been reported.

The first year's growth of the biennial sweetclover makes a very good hay. If allowed to reach considerable height before being mowed, however, it will be stemmy, and the leaves will shatter badly. The second year's growth should be used for pasture rather than as hay for the following reasons: (1) It grows so rapidly that in order to get a reasonably fine hay it must be cut very early in the season, when curing is difficult; and (2), while many farmers have successfully fed second year's growth for a long time, there are recorded instances in which such hay developed some substance during curing that prevented the normal clotting of blood from a wound and led to fatal internal or external hemorrhages in the animals. It is unsafe to dehorn animals that are being fed considerable quantities of such hay.

GRASS HAYS

Grass hays include timothy, redtop, bluegrass, Sudan grass, sorghum, and others. As a rule these hays are less palatable than legume hays and contain less protein and mineral matter, and therefore are not so good as legume hays for milk production. However, if the grass hays are harvested at an early stage of maturity and are properly cured, they may be equal to legume hay cut at the usual stage of growth in both palatability and content of protein. There is evidence, also, that a high nitrogen content of the soil caused by either the growth of legumes or the addition of fertilizer increases the protein content of grasses.

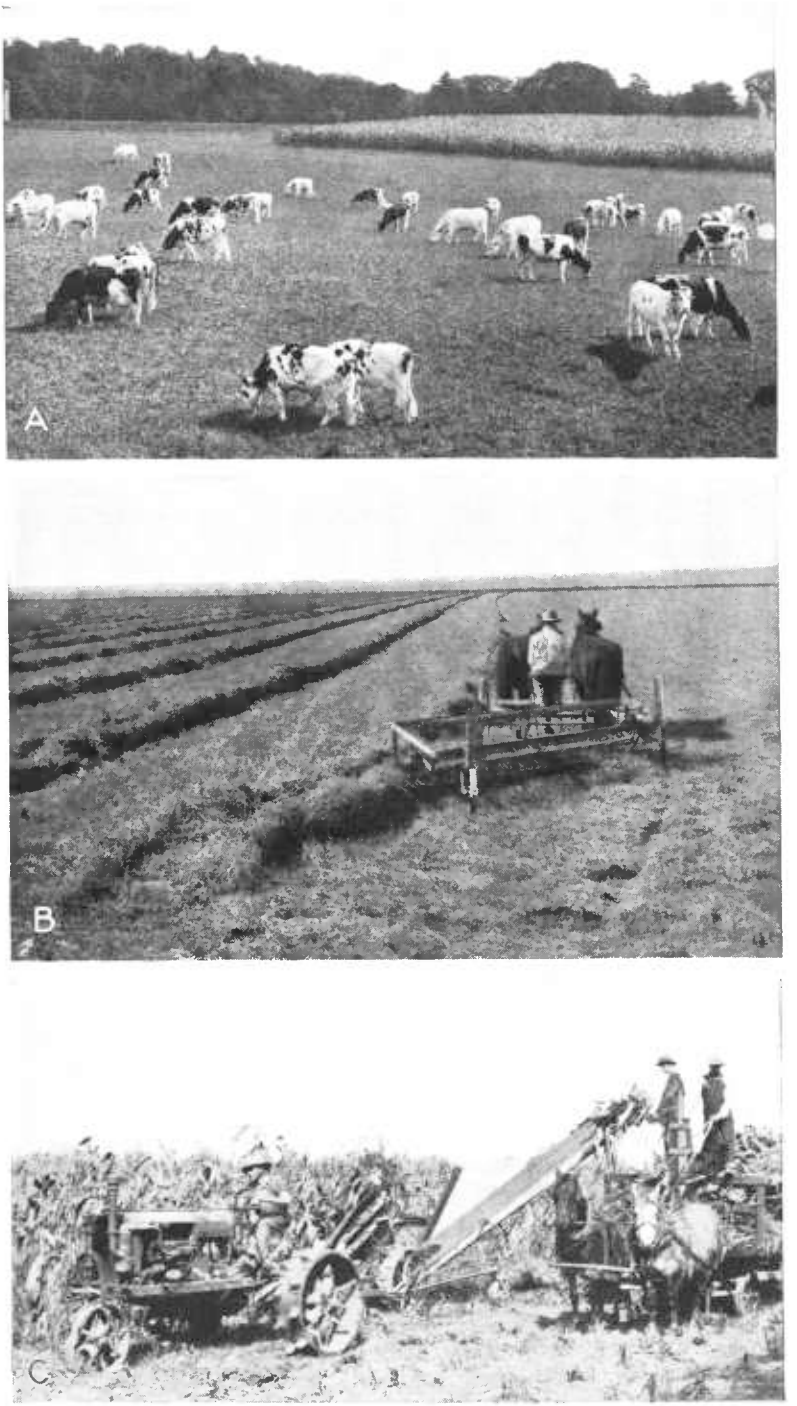


FIGURE 1.—Three sources of cheap feed for dairy cows: *A*, Pasture; *B*, alfalfa; *C*, corn for silage.

GRAIN HAYS

Grain hays include those made from the small cereals, such as oats, barley, wheat, and rye. To make the best hay these cereals should be cut when the grain is in the milk. At this stage the cured leaves retain their green color and if carefully handled do not crumble badly. In composition the grain hays are similar to grass hays, being rather low in protein in proportion to the carbohydrates and fats. The awns on some varieties of barley and wheat make these hays decidedly undesirable for feeding.

MIXED HAYS

Although the Handbook of Official Hay Standards gives a specific definition of mixed hay, for the purpose of this discussion any combination of a grass and a legume is called a mixed hay. Its composition is influenced by the kind and relative quantities of legumes and nonlegumes which it contains, the stage of maturity when cut, and the manner in which it is cured. Although early-cut grass often contains as much protein as the legumes, it is safe to conclude that, on an average, mixed hays, when cut at the same or corresponding stage of maturity as the legumes, contain only about two-thirds as much protein as do the legumes.

The practice of using a mixture of legumes with some other crops is to be commended where because of soil conditions or habits of growth the legumes cannot be depended upon for hay when sown alone. Some of these mixtures are oats and vetch, wheat and vetch, oats and peas, Sudan grass and soybeans, as well as clover and timothy, and alfalfa and timothy. These can all be made into a good quality of hay.

STRAWS

The cereal straws are high in fiber, low in proteins and minerals, constipating, and lacking in palatability. Cows, however, will eat small quantities of these, especially oat straw, even when they have access to plenty of good hay. Probably the consumption of a small quantity is beneficial.

If there is a shortage of other roughages or they are high priced, the straws from the cereal grains may well be used more extensively than is the usual practice. If properly supplemented with feeds rich in protein and minerals, these straws can furnish the greater part of the roughage for dairy cows, particularly that for low producers or dry cows. Heavy milk production cannot be expected when cereal straw is the sole roughage.

Legume straws contain more protein and minerals than the cereal straws and for this reason are generally superior to the cereal straws provided they have been saved in good condition.

CORN STOVER

The edible portion of corn stover is similar to timothy or other grass hay in composition, effects, and value. If the corn is cut rather early and the stover is shocked or stored in such a way that it will not be leached by rains, it makes a fairly good feed.

One great objection to corn stover is the waste in feeding it. When it is fed without being chopped or ground the waste amounts to one-third to one-half the total. Chopping or shredding it improves the

completeness of consumption, and grinding it may put it in such condition that there will be no waste whatever. Corn stover dries out very slowly. If it is stored in a chopped, shredded, or ground condition before the moisture content falls to 20 percent or less, it will heat and mold. For this reason it must be chopped or ground as it is used, until the moisture content becomes low enough so that it can be stored without spoiling.

SORGOS AND GRAIN SORGHUMS

In the Southwest if the sorgos (sweet sorghums) are seeded thick enough in drills or broadcast so that large stems will not develop, they may be made into hay much the same as Sudan grass. However, if they are seeded in rows as is the usual practice in most places where they are grown, they cannot be made into hay as the stalks become too heavy. Usually sorgos are put up in cocks and allowed to remain in the field until needed for feeding.

What has been said regarding corn stover applies in general to the stovers of the grain sorghums. Both the sorgos and the grain sorghums are low in protein and should be supplemented with some feed or feeds richer in protein.

SILAGES

Any crop which contains enough fiber and neither too much nor too little moisture may be made into silage successfully. In general the silage will be similar to the crop material from which it is made in respect to both palatability and nutrients contained. Unpalatable or inedible materials cannot be made into satisfactory feeds by putting them in the silo.

Taking into consideration the yield, sureness of crop, ease of handling, and feeding value, corn is generally the best silage crop, although in certain regions where corn does not thrive the sorghums, small grains, and even sunflowers and Russian-thistles have proved to be more or less satisfactory substitutes. Grasses and legumes ordinarily used for pasture and hay are being made into silage successfully.

Crops put into the silo should be dry enough so that there will be little or no leakage of juices from the silo, and wet enough so that they will pack closely and force out the air. They should also be chopped fine to permit close packing. Legumes, and perhaps grasses also, should be allowed to wilt if necessary to bring the moisture content below 70 percent. If the crops are harvested during a dry period or in good drying weather, wilting may not be necessary.

The carotene content of silage has been found to be high if the crop from which it was made had a high carotene content and the silage was packed tightly enough to exclude the air. Crops that have become discolored by frost before being cut, or by rains or dews after being cut, will have a low carotene content, and the resulting silage will likewise be low in carotene. Because of its carotene content good silage is especially valuable as a supplement to hay that has become discolored as a result of late cutting, faulty curing, or storage with too much moisture. Silage from nonlegumes, if properly made, is palatable and has a good appearance and odor and a high carotene content. Under American conditions, there is no evidence that adding mineral acids or any other substance to such silage is

beneficial. To what extent mineral acids and molasses or other carbohydrate materials are useful in improving the quality of silage made from legumes is still undetermined.

SOILING CROPS

Soiling crops, which are harvested and fed immediately in their fresh green state, are valuable as substitutes for pastures or as supplements to them. A cereal, Sudan grass, or a legume, or a combination of the cereal or Sudan grass with a legume, is most commonly used, but any palatable green feed may be fed. Soiling crops are similar to pasture in nutritive value.

ROOT CROPS AND OTHER SUCCULENTS

Most of the common root crops, such as mangels, beets, rutabagas, turnips, and carrots, are valuable dairy feeds. Because they are low in fiber and high in water content these feeds are sometimes spoken of as watery concentrates. Materials which may be fed in the place of silage or the root crops are apples, apple pomace, pumpkins, cull potatoes, sweetpotatoes, kales, sugar-beet pulp, and wet brewers' grains. The value of each depends largely upon the content of dry matter. Wet beet pulp and pumpkins are low in this constituent, having only about one-third as much dry matter as sweetpotatoes and wet brewers' grains.

PASTURE

Pasture grass or other green forage appears desirable for continuous high milk production. Such material possesses a property which under certain conditions promotes the assimilation of mineral matter. A cow on good pasture is able to replenish the stores of minerals and vitamin A which are likely to have become depleted during the winter if an unsuitable grain mixture and a poor quality of roughage have been fed. Since pasture grass is bulky and watery, most cows are unable to eat enough of it alone to support a very large flow of milk. As the grass matures there is a steady decline in the percentage of protein and an increase in the content of dry matter and fiber.

CEREAL GRAINS

In general, cereal grains are palatable, rich in carbohydrates, low in fiber and minerals, comparatively low in protein, and high in total digestible nutrients. Corn stands at the head of the list in palatability and percentage of total digestible nutrients. Barley and the sorghums are almost as desirable in these respects. Oats have a higher fiber content than any of the other cereals but contain more protein than does corn or barley. Wheat is similar to corn, in composition and feeding value, and when the price of wheat per pound is less than that of corn it will pay to substitute wheat for at least a part of the corn in grain mixtures for dairy cows. Rye is high in content of nutrients, but because it lacks palatability it is used very little as a dairy feed.

LEGUME SEEDS AND OIL MEALS

The legume seeds and so-called oil meals contain much protein and have a high nutritive value. The legume seeds used for dairy feed include the field pea, velvetbean, soybean, and peanut. The oil of

the soybean and peanut is usually extracted and used commercially, the residue being used for feeding purposes. In that form they are similar in feeding value to linseed meal and cottonseed meal, which are also residues from the extraction of oil from the flaxseed and cottonseed, respectively. All these feeds except the velvetbean are palatable, but their high concentration makes it desirable that they be fed with more bulky material. Cottonseed meal contains a comparatively large percentage of phosphorus, linseed meal and soybean oil meal somewhat less, and peanut meal the least of all.

BYPRODUCTS

A number of byproducts are used for feeding, but only the most important ones are discussed here.

Wheat bran contains much phosphorus and a medium amount of protein and is bulky. These characteristics make it a valuable ingredient of all dairy rations.

Hominy feed is comparable with corn meal in nearly all respects. The two are thought to be equal in feeding value pound for pound. Hominy feed is not so likely to heat and mold as is corn meal.

Corn-gluten feed is rather high in protein, averaging 20 percent or more in the best grades. It is somewhat bulky and not quite so palatable as hominy feed and corn meal. Corn-gluten meal has a high content of protein and for that reason is sometimes used to replace the oil meals in the ration.

Dried brewers' grains are similar to corn-gluten feed in composition, but they contain more fiber and less total nutrients.

Dried distillers' grains if made from corn have a higher content of protein and total nutrients than brewers' grains. If made from rye, however, they are unpalatable and low in feeding value.

Coconut meal, which is widely used on the west coast, contains only a medium quantity of protein. Although it is not especially palatable, it is used to advantage as one of the ingredients of the concentrate ration. Its price, too, generally serves to make it attractive.

Tankage and fish meal are both being used successfully in the rations of dairy cattle. These feeds not only have a high content of protein but the calcium and phosphorus are also high, which makes them of especial value in a ration that otherwise is deficient in these essential minerals.

Dried beet pulp is low in protein, bulky, and fairly palatable. Apparently cows are unlikely to be injured by eating large quantities of the pulp which is one reason why beet pulp is so widely used in the rations of high-producing cows.

Both beet and cane molasses are very palatable and when mixed with some feeds ordinarily unpalatable cause such feeds to be eaten more readily and completely. Carbohydrates make up about two-thirds of the weight of molasses. Sometimes the price of molasses is so low that some feeders consider that the nutrient content alone justifies its purchase. Both kinds of molasses are laxative, that from the sugar beet being more so than that from the sugarcane.

COMMERCIAL MIXED FEEDS

Many excellent mixed feeds containing only high-quality ingredients are on the market. Laws governing the sale of mixed feeds require that their chemical composition be stated on the bags. An

examination of these analyses will enable the buyer to form a better opinion of the value of the feed. The lower the fiber content the more valuable the feed. A high fiber content indicates the presence of oat hulls, corncobs, cottonseed hulls, ground roughage, or other low-grade material. The analyses of many mixed feeds, however, do not give complete information on the composition—omitting for instance the sources of protein, or the content of phosphorus and calcium. Such formulas are known as "closed" formulas. The "open" formula, on the other hand, gives also the kind and quantities of the different ingredients in the mixture and thus helps the buyer to judge the value of the feed. If the analysis of a feed is satisfactory, if the variety of sources is ample, if the odor and appearance of the feed are good, and if the cows like it, the requirements for a good feed are largely complied with.

COMPOUNDING THE GRAIN RATION

In compounding the grain ration several factors besides cost must be considered. They are bulkiness, palatability, and the content of protein and minerals.

PROTEIN CONTENT

One of the most important considerations in preparing a grain ration is to see that it contains sufficient protein from a number of sources so that every cow will be amply nourished. It is impracticable, however, to furnish a perfectly balanced ration for each dairy cow in the herd because the requirements of the cows differ with their production. It is better to have some cows get more protein than they need than to attempt to supply a perfectly balanced ration for every cow. The quantity of protein that must be supplied in the grain depends upon the quantity of protein in the roughage. The approximate percentages of protein in the grain rations to be fed with different roughages are shown in table 1. There are hundreds of combinations that may be used; the mixtures shown in the table are made up of certain standard feeds. Other feeds may be substituted wholly or in part for the feeds specified.

TABLE 1.—*Grain mixtures having different protein contents to be fed with different roughages*

Roughage	Approximate protein content desired in grain mixture	Grain mixture			
		Ground corn	Ground oats	Wheat bran	Cottonseed meal
	Percent	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Legume hay alone	12	400	200	200	
Legume hay and silage or mixed hay [1] alone	16	300	200	200	100
Mixed hay [1] and silage	20	200	200	200	200
Grass hay and silage or either alone	24	100	200	200	300

[1] One-half grass and one-half legume.

Part or all of the corn in the mixtures in table 1 may be replaced by barley, wheat, kafir, spelt, or hominy feed. Part of the oats may be replaced by barley, wheat, kafir, spelt, hominy feed, or corn. Two parts of gluten feed or dried brewers' grains may replace one part of oats and one part of cottonseed meal. Linseed meal, peanut

meal, soybean oil meal, or fish meal, may be substituted for part or all of the cottonseed meal. High-grade tankage may be substituted for cottonseed meal at the rate of 2 pounds of tankage for each 3 pounds of cottonseed meal.

MINERAL CONTENT

The minerals most likely to be deficient in the ration are common salt, calcium (lime), and phosphorus. Add common salt to the grain mixture at the rate of 1 percent. In addition to this allow the cows access to salt at least once a day.

Although mineral mixtures are sometimes added to the grain ration, better results are obtained by making up the ration in such a way as to supply the needed minerals in the natural foodstuffs. None of the concentrates are high in lime. To provide this mineral, see that the cow receives plenty of legumes either in the form of pasture, soiling crops, or hay so cured as to retain its green color and leafiness. If the grain ration contains a liberal proportion of wheat bran or some of the oil meals the phosphorus needs of the cow will be met. Soils containing an abundance of lime and phosphorus will produce forage richer in these constituents than will soils deficient in them. For this reason liming and fertilizing the soil will go a long way toward maintaining proper mineral nutrition of the dairy herd.

Feeding inorganic mineral supplements containing calcium and phosphorus is advisable only under certain conditions. When cows are on grass pastures, the soils of which are poor in lime or phosphorus or both, some benefit is derived from feeding steamed bonemeal. Mix it with the grain at the rate of 1 or 2 percent. If the cows receive no grain while on pasture, put the bonemeal in a box where it will be accessible to the cows. In certain sections of the United States the soil is so deficient in phosphorus that feeding the forage produced thereon to dairy cows in the winter leads to serious malnutrition. This may be corrected by feeding steamed bonemeal.

Steamed bonemeal is valuable as a source of both calcium and phosphorus. Some bonemeals are steamed more than others. The more the meal is steamed the less the organic matter left in it and the less odorous the product. The cows greatly prefer the bonemeal which has been only slightly steamed, and for this reason it is the better form to use where cows have access to it at will. In any case the bonemeal should be steamed sufficiently to destroy any disease-producing organisms. Since such bonemeal spoils when it gets wet, the box containing it must be protected from the rain. When the bonemeal is fed in the grain mixture its palatability is not an important factor, and therefore it makes little difference which form of the product is used.

The use of complex mineral mixtures is not advised, since calcium and phosphorus, the only minerals likely to be deficient in the ration, can be obtained more cheaply in bonemeal than in the prepared mixtures. Raw rock phosphate may prove harmful because of its content of fluorine.

In addition to the minerals just mentioned, it is sometimes necessary in certain regions to supply iodine in the ration. This can be done effectively by sprinkling on the feed of the pregnant cow once each week a tablespoonful of a 5-percent solution of potassium or sodium iodide, or fish meal can be included as one of the constituents of the ration.

BULKINESS AND PALATABILITY

Some feeds become pasty when moistened; in this condition the digestive juices cannot readily act on them. Combine such feeds with more bulky ones in order to prevent this condition. The best feeds for this purpose are wheat bran and ground oats. If the grain ration contains one third to one half of either or both of these two feeds it will not stick together when wet. Dried beet pulp or a ground roughage may also be used for this purpose. In some cases the concentrates are mixed with the silage at feeding time. Cobs are sometimes ground with the corn in order to provide bulk in the grain ration. Although the cobs do serve this purpose, they add very little nutriment.

Grain mixtures should be sufficiently palatable so that every cow will consume as much as is required for highest milk production. Fortunately, most concentrates of good quality are palatable. Among these are corn, barley, oats, wheat bran, beet pulp, and the oil meals. Velvetbeans, rye, and some of the other uncommon feeds lack palatability.

Molasses is used extensively, especially in ready mixed rations, to make the mixtures more palatable. Dairy farmers use molasses also to render low-grade roughages more appetizing as well as to replace corn or other carbohydrate feed when the relative prices are favorable to molasses. Cows will eat low-grade hay more completely if molasses is poured over it. Before adding the molasses, mix with it enough water to make the solution flow freely. On account of the laxative nature of beet molasses 3 pounds per day for each cow is the maximum amount that can be fed safely. Cane molasses can be fed safely in larger amounts.

KINDS AND QUANTITIES OF FEED TO USE

In general, dairy cows should be fed all or nearly all the roughage they will consume in the form of pasture grass, soiling crops, hay, or silage. If such feeds are home-grown, the nutrients in them are usually cheaper than those in concentrates; the cow's digestive system is primarily adapted to handling coarse feed, and cows generously fed on roughage rather than concentrates are less subject to digestive disturbances. If the dairyman buys both the hay and the grain, however, and the hay costs more than two-thirds as much as the grain, he may well limit the quantity of hay and feed more grain. In feeding high producers, however, care must be taken not to feed concentrates too heavily and throw the cow off her feed. Such cows should receive enough nutrients in their roughages so that the grain allowance may be kept at a safe level. On the other hand, cows producing a small or medium quantity of milk may be fed on roughage alone if the roughage is of good quality and relatively cheap.

SUMMER FEEDING

Pasture provides the cheapest summer feed. This is because the labor cost of maintaining pastures is only a fraction of the labor cost of raising harvested crops.

Ideal pasture herbage is young, tender, abundant, and palatable, and is grown on a soil rich in minerals, especially lime and phosphorus. Immature grass not only has a higher protein content but also is

more palatable than that which has reached the usual haymaking stage. In many pastures cows will graze on the spots of short immature grass rather than on the grass that has become more mature. Early in the spring, although the grass is tender and palatable, it should not be grazed until it has made enough growth so that a cow can gather her fill in a few hours.

Pastures differ so much in quality that specific pasturing recommendations are impossible. On good grass pasture in many sections of the United States cows that are producing 1 pound of butterfat or less a day maintain their production and body weight for the first month or so just as well without grain as with it. But from this time until fall additional feed must be supplied because the grass becomes either less abundant or more mature, and the intake of grass is therefore much diminished. If the rainfall is sufficient to keep the pastures fairly abundant or if good temporary pastures are available so that the cows will always have their fill of roughage, grain alone will probably suffice as a supplementary feed. Under less favorable conditions, however, soiling crops, hay, or silage should be fed, in order to provide an adequate quantity of roughage.

In deciding on the kinds and quantities of feeds to be used in supplementing the pastures, the condition of the cows should be taken into consideration. In most cases, if the cows are allowed to become very thin, the result will be a much-reduced milk flow, which cannot be regained during that lactation period by subsequent more liberal feeding.

Soiling crops are often used as supplements to short pastures and sometimes as substitutes for them. For the former purpose corn and, to a lesser extent, alfalfa, soybeans, or Sudan grass are the most generally used. Since these crops are rather generally raised on dairy farms, they may require no additional fields or special attention. Therefore, they make the cheapest and best soiling crops for use late in the summer. When soiling crops take the place of pasture entirely, a continuous supply of them must be provided throughout the summer, a fact that necessitates special crops or special seedings to fill the gaps between the crops regularly raised. The crops to be raised differ so much with climatic and soil conditions that specific recommendations for them are not possible.

For summer feeding, silage, where it is available, is generally cheaper and more convenient to use than are soiling crops. Silage left over from the previous season may be fed after the spoiled top layer has been removed, an early maturing crop may be ensiled and used as needed, or silage made from the early growth of grass may be used for feeding when the pasturage becomes inadequate. Hay may also be used to supplement pastures, particularly if the nutrients in the hay are obtained at a relatively low cost.

The crops to be used for supplemental pastures depend largely on the season at which such pastures are needed and on the adaptability of the crop to the section where it is to be grown. Sudan grass is perhaps used more than any other crop as a supplemental pasture, although in the southern half of the United States lespedeza is rapidly coming into more general use. One of the advantages of lespedeza is that it does not require reseeding every year. Sweet clover in the Midwest and the aftermath of hayfields in the Northeast are being used extensively for supplemental pasturage. In some sections the

small grains provide pasturage during the colder seasons of the year when the permanent pastures are dormant. Alfalfa also is coming into more general use as a pasture crop in many sections of the United States. More complete information regarding pastures is contained in Miscellaneous Publication 194, A Pasture Handbook, issued by the United States Department of Agriculture.

WINTER FEEDING

In winter the cows should be given all the good hay they will eat, twice a day. If they will eat corn stover or straw in addition, there is no objection to letting them have it. When the hay is fed with a medium quantity of silage, 1 to 1½ pounds a day of medium to good hay for each 100 pounds of live weight will be consumed. The same quality of hay fed without the silage will be eaten at the rate of 2 pounds a day for each 100 pounds of live weight. More nutrients are consumed when silage or roots are fed with the hay than when hay is fed alone, if the hay is of medium or poor quality. However, if the hay is of the best quality more nutrients may be consumed than if a portion of it is replaced by silage. No. 1 alfalfa hay, fed as the sole ration and to the limit of the cows' appetites, will be consumed at the rate of 3 pounds or more of hay for each 100 pounds of live weight.

In most sections of the United States the silo is the cheapest, surest, and most satisfactory means of providing a succulent feed for winter use. The amount of silage to be fed ranges from about 20 pounds per cow per day to 50 pounds per cow per day, depending on the size of the cow and the quantity of other roughages fed. If hay is scarce or high-priced, reduce the amount of hay and feed more silage. The usual quantity of silage advised is about 3 pounds per day for each 100 pounds of live weight.

Although root crops are low in fiber, they should not be fed in place of concentrates but, like silage, as a supplement to a ration of hay and concentrates. The quantity of root crops to feed depends upon their cost as compared with that of other feeds, upon the kinds of roots, and upon the other ingredients in the ration. In general, cows receiving such feeds as pasture, soiling crops, or silage do not need root crops. If root crops are expensive, feed only about 30 to 50 pounds a day. If relatively cheap, as may be the case in some regions, feed twice this quantity. More mangels and turnips than sugar beets or sweetpotatoes may be fed because they contain more water. Feed only moderate quantities of beet tops, because they are more laxative than the beets themselves. Beet tops as well as the root crops should be free from excessive dirt when fed.

Frequently the grain requirement for high-producing cows is so great that the necessary quantity cannot be fed without endangering their health. In such cases the quantity of grain may be kept at a safe level and the additional nutrients supplied by feeding beet pulp either dry or soaked in about three times its weight of water.

Experiments at the dairy experiment farm at Beltsville, Md., show the following feeding practice to be fairly satisfactory: Feed each cow about 3 pounds of silage for each 100 pounds of live weight. A cow weighing 800 pounds, therefore, would receive 24 pounds of silage, whereas one weighing 1,200 pounds would receive 36 pounds of silage. Twice a day give the cow all the good hay she will eat, ex-

clusive of coarse stems and weeds. To Jersey cows yielding 10 pounds of milk or less give no grain, but for every pound over 10 give 0.5 to 0.6 pound of grain. A Jersey cow giving 20 pounds of milk, therefore, would receive 5 or 6 pounds of grain; one giving 30 pounds of milk would receive 10 or 12 pounds of grain. To Holsteins yielding 16 pounds of milk or less give no grain, but for every pound over 16 give 0.4 pound of grain. A Holstein cow yielding 30 pounds of milk, therefore, would receive 5.6 or approximately 6 pounds of grain, whereas one giving 40 pounds would receive 9.6 or approximately 10 pounds of grain.

Although this system of feeding has not been tried out with other breeds, it is probable that Guernseys should receive about 0.5 pound of grain for each pound of milk above 12 and Ayrshires 0.45 pound of grain for each pound of milk above 14. If the hay is of poor quality the cows will not eat so much of it and therefore must have more grain. On the other hand, if the hay is of the best quality the cows will eat more of it, and less grain than specified will be required. If the roughage is the very best, a cow may produce 1 pound of butterfat daily, or even more, on roughage alone, without losing weight. The above directions are based on the supposition that the cow eats at least 1¼ pounds of hay per day for each 100 pounds of live weight. In the absence of exact weights, a feeder must be guided largely by the condition of the individual cows. If any are getting thin, give them more grain; if they are getting fat, reduce the grain. For most economical production, cows should be kept in a medium state of flesh, neither fat nor thin.

Record the quantity of feed consumed by each cow. A convenient and practical way to feed concentrates is to use a cart or truck to which are attached feeding charts or cards showing the amount of feed to be given each cow. A small blackboard can be attached to the cart and the figures recorded. A spring-balance scale suspended above the cart on an arm is of great help. If the allowance of silage and hay is weighed occasionally, the quantity can be measured with reasonable accuracy.

BEFORE AND AFTER CALVING

The cow that has been dry for 6 weeks to 2 months and has been liberally fed while milking, as well as during the dry period, should be in good flesh at calving time. Ground oats mixed with wheat bran and linseed meal are good feeds to use before calving. The drinking water should not be too cold.

For a few days after calving, cows should be fed sparingly. This will help to prevent digestive disturbances and to reduce the swelling in the udder. In general, after calving the appetite of thin cows is somewhat keener than that of fat cows, and their udders reach normal size in a shorter time. For these reasons the rations of thin cows may gradually be increased to the full amount in about 2 weeks and those of fat cows in 4 weeks or more.

After a cow has been fresh from 3 to 6 weeks, her weight has usually reached the minimum and her production the maximum. Thereafter feed her enough to maintain her body weight as well as to produce milk; otherwise the production of milk will decrease rapidly. She should make a slow but steady gain in weight from this time until she calves again in order to bring her to the same condition as that

of the previous year. The total gain, including the weight of the fetus, should be from 100 to 250 pounds, depending upon the breed and condition of the cow. It is better to feed her enough to allow some of this gain to be made while milking rather than to try to accomplish it all during the dry period. Such feeding will undoubtedly result in more milk than if the weight is kept stationary. The feeding practice recommended above will furnish sufficient nutrients for cows to make a slight gain but still not enough to bring them back to proper weight before drying off. Some of the flesh must be put on when cows are dry.

FEEDING SUGGESTIONS

Keep cows on good succulent pasture as much of the year as possible.

The order of feeding roughage, succulents, and concentrates has no effect on milk production.

Feed concentrates as often as the cow is milked. Roughage and succulents may be fed twice a day.

Feeding concentrates wet has no advantage over feeding them dry.

Always grind or roll grain for dairy cows.

Beet pulp may be fed either dry or soaked. If water is added, soak at one time only as much pulp as can be fed in 24 hours.

Cows will eat more of a coarse, stemmy hay if it is run through a cutter, although the digestibility of the feed is not affected.

There is no advantage in mixing ground roughages and ground concentrates except that a small quantity of ground roughage may be used to lighten a heavy ration of concentrates.

Corn fodder cut and treated with a converter, which changes some of the starch to sugar, has been found to possess no advantage over corn silage in cost, palatability, or effect on quantity of milk produced.

Always feed highly flavored feeds just after milking. It is advisable to do all the feeding at this time.

Before feeding such feeds as root crops, potatoes, and apples, run them through a feed chopper in order to prevent choking.

Shredding corn stover adds to the convenience in feeding, lessens the waste, and makes the portion refused better for bedding.

A cow not in good condition because of disease may be helped by a tonic. The tonic is a medicine and should be used as such. A healthy, well-fed cow needs a tonic no more than a healthy person needs medicine.

U. S. GOVERNMENT PRINTING OFFICE: 1936

For sale by the Superintendent of Documents, Washington, D. C. - - - - - Price 5 cents